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TRANSACTIONS

OF THE

AMERICAN INSTITUTE

OF

ELECTRICAL ENGINEERS.

SPECIAL MEETING, FEBRUARY 14TH, 1888.

SUBJECT:

Alternating Current Electric Motors.

BY DR. LOUIS DUNCAN.

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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

VOL. V. New York, April, 1888. No. 7.

SECRETARY'S BULLETIN.

The twenty-fourth meeting of the Institute, announced for March 13th, was cancelled on account of the great snow storm, which caused almost a general suspension of business in New York city and vicinity. The paper prepared for the occasion by Lieutenant F. Jarvis Patten will be read at the general meeting, May 16th. The Council extends a general invitation to members and associates who desire to present papers, to communicate with the Secretary in order that convenient dates may be fixed for their discussion. The Institute through its printed Transactions, and the courtesy of the electrical press, is enabled to give a world-wide range of publicity to all papers brought before it.

The annual meeting of the Institute for the election of officers, and the transaction of other business, will be held on May 15th, the third Tuesday in the month, as provided by the rules.

A general meeting will convene on the morning of May 16th, and continue during the day.

Further particulars will be given as usual, by mail, in advance of these meetings.

At the regular monthly meeting of Council, held March 6th, the following named gentlemen were elected to associate membership in the American Institute of Electrical Engineers, their applications having been properly endorsed.

Townsend Wolcott, Julien Electric Traction Co., New York.
Frederick Reckenzaun, Electrician, Electrical Accumulator Co., New York.
Philip Lange, Electrician and Supt. of Detail Dept. Westinghouse Electric Co., Pittsburgh, Pa.
Samuel S. Dickenson, Direct U. S. Cable Co., Hazelhill, Nova Scotia.
Malcolm Walker, Manchester, Eng.

Fremont Wilson, Sup't Julien Electric Traction Co., New York.
John Langton, Chief Engineer, Edison Machine Co., Schenectady, N. Y.
Gustav A. Liebig, Jr., Electrician, The Baxter Electric M'f'g and Motor Co., Baltimore, Md.
Herbert G. Smith, Electrician, Compania Luz Electrica, Quezaltenango, Guatemala.
George M. Phelps, (retired,) 91 Division Ave., Brooklyn, N. Y.
S. F. B. Morse, Saybrook, Conn.

The twenty-fourth meeting of the Institute is announced for the evening of April 10th, when a paper will be read by John W. Howell, Electrician, Edison Lamp Company, on the "Maximum Efficiency of Incandescent Lamps."

The annual and general meetings in May will take the place of the customary monthly meeting.

The continued growth of the Institute has made it necessary to establish suitable quarters in the business section of the city for the accomodation of its files of periodicals and its accumulating literature, as well as for the ordinary meetings of Council and of working committees. An office has therefore been leased in Temple Court, No. 5 Beekman Street, close to the General Post Office, etc., and preparations are now being made for its occupancy by the Secretary for the purposes above mentioned. The building being strictly fireproof, will be a most suitable repository for electrical books, pamphlets, papers, etc., the acceptance of which, from the friends of the Institute, has been postponed until they could thus be properly provided for. Members and well-wishers of the Institute who desire to give or lend books, models, relics, etc., will now please communicate with the Secretary, who will make the necessary arrangements for shipping and receiving them. The room will be ready for use about May 1.

It is with much pleasure also that the Secretary announces the continuance of the cordial relations that have so long existed between the Institute and the American Society of Civil Engineers—relations from which the happiest results may be confidently expected. The meetings for the reading and discussion of papers will be held at the house of that society as heretofore, and the Institute will in this manner enjoy the advantage of a rendezvous uptown as well as down town. The Secretary trusts that all out-of-town members visiting New York will avail themselves of the facilities afforded by the new office in Temple Court, and will be glad to receive suggestions from them as to desirable measures for increasing the benefits.

Read before the twenty-third meeting of the Institute, New York, February 14, 1888.

ALTERNATING CURRENT ELECTRIC MOTORS.

BY DR. LOUIS DUNCAN.

The alternating system of electrical distribution, possessing as it does many advantages for distributing electrical energy over extended areas, possesses certain disadvantages, among others that of not, at present, allowing the use of electric motors for the distribution of power. Let us, before taking up the special subject for consideration to-night, briefly review the general subject of alternating current distribution.

In this system are employed currents of high and constant potential, varying from positive to negative many times a second. If we represent current and potential by curves, whose heights above a horizontal line represent ampères or volts, the horizontal distance representing intervals of time, we will have something

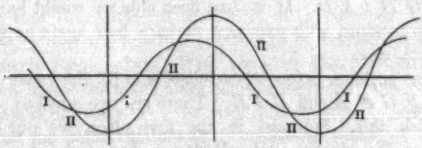

Figure 1.

like the following: Fig. 1. *II* representing current, *I* representing electromotive force; the maximum value of the current lagging behind the maximum of E. M. F. in a way that you were shown recently by Mr. Stanley.

The high potential used in the dynamo or primary circuit would not be suitable for incandescent lighting and would be dangerous; it is, therefore, reduced to a low potential at points of

consumption by "transformers;" that is, induction coils working backward. Now, the whole beauty of the system lies in this; that by using high potentials in the primary circuits we can transmit a great deal of energy with comparatively little current and, therefore, with little loss in the lines. This enables us to use small conductors and to avoid the large investment in copper necessary in distributing energy by the direct system.

In any central station supplying electric lights, the full capacity of the plant is utilized but a short time during the day, and taking the whole twenty-four hours, we will find that we have sold an amount of energy equal to a half or a third—perhaps even less—of the amount we could supply, supposing there was a demand for it all. Let us represent by a curve, Fig. 2, the

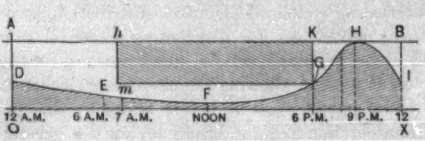

Figure 2.

amount of current used during the day in a constant potential system; the potential being constant, the energy will vary with the current, it being equal to *E C*.

The amount of energy we could have sold is represented by the total area *A O X B;* the amount we have sold is the area *D E F G H I X O*. If we had been able we would have three times the receipts, with expenses perhaps half again as much as in the first case.

A great problem before electricians is to fill the vacant spaces, *A D E F G H A* and *H I B*. There are two ways to partially accomplish this. Suppose, in the first place, we put electric motors on the circuits and sell power during the day. What effect will that have on our diagram? If the motors are at work from 7 A. M. to 6 P. M., we can sell so much power as will at no time make the sum of the power and the energy used for lights greater than the maximum capacity of our station. The area representing the power we can thus sell, is shown by *G K h m* on the diagram. The total solid part of the diagram is all that an alternating system can supply; the direct system could fill the entire area by using storage batteries.

Our knowledge on the subject of alternating currents is largely due to the work of M. Joubert and Dr. John Hopkinson. The latter showed first that alternating dynamos could be coupled in parallel, and afterward that one dynamo could be used to drive another as a motor. He brought forward experiments tried by Prof. Adams and himself, in which one dynamo had driven another, the latter doing mechanical work. Mr. Siemens at the same time, in 1885, described experiments where he had driven both alternating dynamos and ordinary series motors by alternating currents. Dr. Hopkinson's mathematical work assumes that the curve representing E.M.F. is a simple sine curve; that is, that $E = E_0 \sin 2\pi \frac{t}{T}$; it is important to notice, however, that his principal conclusions do not depend upon this assumption, but would be true if the E. M. F. were any periodic curve. Since that time nothing of importance has appeared on the subject excepting two short papers, one by Mr. Kapp on "The Maximum Work Obtainable from a Given Source of E. M. F.;" the other by Mr. Blakesly on "Conditions of Maximum Efficiency in the Case of Transmission of Power by Alternating Electric Currents."

In all of the mathematical work done on this subject it has been assumed that the various E. M. F.'s may be represented by a sine curve, and that only simple electro-magnetic actions enter into the problem. I do not believe that these assumptions are true. Since Joubert's experiments, made in 1881, it has been known that the curve of E. M. F. of a Siemens alternating dynamo, where the external circuit had no statical capacity, was very nearly a sine curve. With some of the machines used today, and under the much more complicated conditions of distribution, this is probably not even approximately true. Neither is it true that the statical actions of the different forms of wire upon each other in the transformers can be neglected. Messrs. Hutchinson, Wilkes and myself have lately experimented on this subject, and we have obtained the curves for the currents in the secondary and primary circuits under many conditions. These observed results do not agree with the results of calculations in the few cases that we have worked out. Until we have fully satisfied ourselves in this matter I will avoid any but the simplest mathematical work.

Alternating current motors are not in successful use; let us

try to find out the difficulties they present and attempt to suggest plans for overcoming them.

The energy being transformed at any moment in any dynamo-electric apparatus—in which I include dynamos, motors, transformers, etc.—is equal to the product of the current by the electro-motive force produced by the apparatus. In the dynamo, for example, the amount of mechanical energy being transformed into electrical is $E\,C$, where E is the electromotive force produced by the dynamo; in a motor the electrical work transformed into mechanical is $e\,C$ where e again is the E. M. F. produced by the apparatus, the counter E. M. F. of the motor. This is true for alternating as well as for direct current apparatus. Generally we have:

Work $= E\,C$. This is + for a dynamo — for a motor.

In alternating circuits E and C are constantly changing. If we represent them by curves, as before, we must multiply each value of C by the corresponding value of E, and if we add all

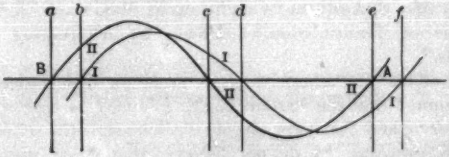

Figure 3.

these together from A to B, Fig. 3, we will have the work done by the current in one period. Now if we consider values above the horizontal + and below it —, we have from e to d a + value of the product, from c to d a — value, from c to b a + value, from b to a —. The total work done then is $[e \text{ to } d] + [c \text{ to } b] - [d \text{ to } c] - [b \text{ to } a]$.

Now we see that if we shift II forward or pull I back, we have this work less even, though the curves themselves remain the same size. Now, this is one of the exceptions I take to the alternating system. In a direct system as the work decreases the current decreases, and the heating of the mains becomes proportionally less, since it varies as C^2; for example, if the maximum loss in the mains of a direct current plant were 10 per cent. of the average, I imagine that the average loss is not over 3 per cent. In an alternating current plant, a decrease in the consumption of

energy decreases the current very little; it simply shifts its position with respect to the E. M. F., and the heating, approximately equal to $\frac{U_0^2}{2} R$, remains nearly constant. A maximum loss of 2.5 per cent. would probably mean an average loss of at least 2 per cent. This same remark applies to transformers and motors, and the average efficiency of the former will be considerably less than the maximum efficiency.

A distinction between continuous and alternating current apparatus is this: In continuous current dynamos and motors the cores making up the windings of the armatures make different angles with the lines of force in the field, and the result, when the armature rotates, is a constant E. M. F. fluctuating but little; in alternating dynamos and motors the alternate coils are symmetrical with respect to the alternate poles, the remaining coils being symmetrical with respect to similar poles of opposite signs. The result is a varying E. M. F., changing as has been shown. In dynamos the effect of this is that the power applied either varies from zero to a maximum each period, or the armature changes its speed at different points and oscillates with a period equal to that of the E. M. F.

Let us now consider what takes place in the case of two motors, one continuous, the other alternating, one between mains where a constant continuous E. M. F. is maintained, the other where there is a constant alternating E. M. F. In the first case representing current and E. M. F. by curves, as we have been doing, we will have two straight lines, Fig. 4, one above, the

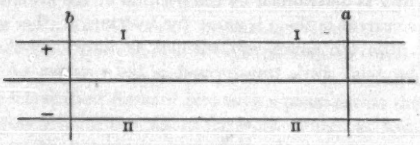

Figure 4.

other below our horizontal axis, the former representing current, the latter the counter E. M. F. of the motor. Reckoning time along the axis we have for the energy transformed in the interval from a to $b = -EC$. As this is $-$ it means that electrical is transformed into mechanical work.

Now, let us consider an alternating current motor built like an alternating dynamo, the field excited by a continuous current. If *A B C*, Fig. 5, are the poles of the field magnets, supposed to

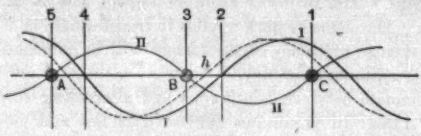

Figure 5.

be excited by a continuous current, then the curve *I I* will represent the counter or motor E. M. F. If our motor is running slowly there will be two or three reversals of current in the time it takes a coil to go from *A* to *B*, Fig. 6, and the product *E C* will be nearly zero, the positive and negative parts being almost equal. Whether it is + or — is somewhat a matter of chance, and if it is — from *A* to *B* it will very likely be + from *B* to *C*. Thus the armature is pushed first in one direction, then in the opposite, and there is no definite tendency for it to rotate as a motor. This brings us to our first difficulty, a simple alternating current motor will not start itself. Let us suppose, however, that it has been started by some means and has reached such a speed that in the time of a reversal a coil shall have moved over the distance between two similar poles. We will have the state of things in Fig. 5, and the armature will continue to rotate. Now the position of the curve *II* is fixed; we will consider the position of *I* as determined by the position of the armature coils when the current in them is zero; for instance, if the speed increases a little the curve will advance as shown by the dotted line. The total work transformed is the product of the two

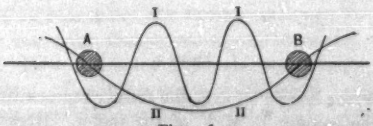

Figure 6.

curves; from 1 to 2 it is —, from 2 to 3 it is +, from 3 to 4 —, from 4 to 5 +. The result is — [1 to 2 + 3 to 4] + [2 to 3 + 4 to 5]: part of the time then the machine is working

as a dynamo, part of the time as a motor; the difference of the values represented by the brackets gives the mechanical work that is really available. Now while the available work is the difference of these areas, the difference becoming small as the load is decreased, the heating is the *sum* C^2R for all the values of the current, and is independent of the position of its curve, as has been pointed out above.

Looking at the figure again we see that from 1 to 2 the armature is pushed forward by the current in the line; from 2 to 3 it is pulled back, since it is acting as a dynamo feeding into the line and can only get the energy to produce the current by decreasing its speed and drawing from its energy of motion. The armature oscillates then and it is evident that the amount of its oscillation depends on the kind of work it is doing. If it is driving heavy wheels or machinery having considerable inertia it will only have to slow down slightly when it becomes a dynamo. If it is lifting weights the amount of oscillation will be considerable.

It is evident that there is a certain position of the curve *I* that

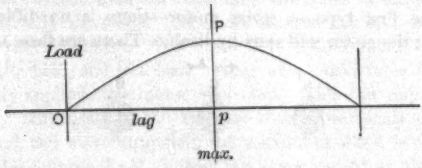

Figure 7.

will make the available work a maximum. If the motor is doing all of its possible work the curve will take up this position; as the load is decreased the speed will increase for an instant until the curve has shifted forward into such a position that the sum of the products — $E\,C$ is equal to the work done. In fact, we can plot a curve representing values of the distance from the point the current curve crosses the axis to the same point when the work is zero corresponding to different loads.

Now the value of this lag, as we call it, cannot be greater than $O\,P$. Fig. 7, for although we might extend our curve on the other side, yet a slight increase in our load will cause the armature to fall back, decreasing the available work, and suddenly stop. It is, in fact, in unstable equilibrium.

Suppose we have found the value of the lag that will give us a maximum value of the work, and have calculated this value by the ordinary mathematical methods employed, the real work we can obtain is less than this, for the current curve oscillates on both sides of the maximum, supposing we *could* work at the maximum; that is, it is only for a very short time in the best position; so that if we take the sum of the work for a period, it will be less than the calculated maximum. In reality we must work slightly in advance of the maximum, for if we were too near it the curve would fall behind P, and will then be in unstable equilibrium and stop. The practical maximum will then vary according to the amount of the oscillation; that is, according to the nature of the work being done.

It seems to me that the possible forms of alternating motors are: (1) ordinary series motor; (2) an alternating dynamo reversed, the field being excited by a continuous current; (3) an alternating dynamo reversed, the field being excited by the alternating current first corrected by a commutator on the shaft; (4) the arrangement suggested by Prof. Thomson, which is described below.

In the first type—a series motor—there is no difficulty in starting; the motor will start by itself. There are these troubles,

Figure 8.

however: the armature and field must both be thoroughly laminated to prevent eddy currents; the magnetism of such large masses of iron being rapidly reversed, will cause losses unless both field and armature are far from saturation; that is, the mass must be great. Again, Mr. Kapp has shown that to obtain the maximum work we must have, approximately, the counter E. M. F. of the motor equal to the E. M. F. of self-induction—a condition almost impossible to realize in practice. The motor must be governed in some way, as it will not govern itself.

The alternating motor with a field fed from the alternating circuit, the current being commutated, will start itself. I do not know if this has been generally recognized. If, in Fig. 8, A and B are poles, and C one of the armature coils, the effects of the

currents will be as shown by the two sets of signs. The effect of either arrangement is to move the armature in the direction of the arrow. When C gets opposite A, the commutator changes the relative directions of the currents in C and A, and C is repelled by A and the armature continues to rotate. The maximum work will, I think, be done when the speed is such that a reversal takes place in a distance A to B. The mathematical investigation is difficult, and until I am satisfied as to the assumptions usually made I will not attempt it. We have as an advantage of this type that it will start itself; a disadvantage is that the fields must be carefully laminated, there is loss in reversing them, and there will be for some speeds considerable sparking at the field commutator. I should not imagine, either, that the work obtainable from such a motor would be as great as if its field were fed by continuous currents.

The motor obtained by reversing an ordinary alternating dynamo has advantages and disadvantages. It perfectly regulates itself and the field magnets need not be laminated; that is, it can be made cheaply. It will give a greater output from a given source of current than corresponding machines of either of the types already discussed. Its disadvantages are that it must be started independently. We must have a continuous current to excite the field, and if a load having any considerable inertia be suddenly applied, the motor will stop. This last objection, by the way, will apply to the type of motor previously discussed, provided, as I have supposed, the maximum work is obtainable when the counter E. M. F. has the same period as the applied E. M. F.

Let us see what means we can employ to start the motor and excite the field. We could start by passing the commutated alternating current through the field as in the second type of motor discussed, changing our connections when the proper speed is attained, so that a continuous current from some external source passes through the field and the alternating current is shut off from it. Another way would be to have on the same shaft with our main motor a motor arrangement such as was described by Prof. Elihu Thomson in his valuable paper on alternating current phenomena, read before the Institute. With this arrangement we can do more than start the motor. Prof. Thomson pointed out that when this auxiliary motor reached a certain speed, it would produce a continuous current in the external circuit of its

armature. This current could be used to excite the field of the main motor. By properly proportioning the number of coils in the main and auxiliary motors, this continuous current would be produced just when the motor had arrived at its proper speed, and it is evident that we can make this current operate an automatic device to make the circuit of the main motor at this moment. I should imagine, however, that a motor made in this way would be expensive and not particularly efficient.

What seems to me the simplest, cheapest, and most efficient means of running alternating current motors is this: build the motor on the same general plan as the dynamo, with such modifications as the different conditions of working impose, and start it and excite the field magnets from a continuous current circuit, run with our alternating circuit, supplied with current by a dynamo at the central station. If we wish to distribute 500 h. p. our continuous circuit should have a maximum capacity of about 50 h. p. To start the motor we should have the following arrangement: there should be two breaks in our armature circuit, one between the regular brushes of the machine, the other at a commutator for the continuous current. At this second break the two ends of the circuit should be taken to alternate bars of the commutator, the number of bars being such that the direction of the current is reversed every time a coil passes a pole. The alternate bars are normally connected by a metal ring pressed against them by a spring; in this case we will have the normal circuit just as if there were no continuous current commutator. On the motor would be a switch-board that would accomplish the following things: If we wish to start we turn the handle of the switch to a certain position; this will short circuit our regular brushes and by the aid of a couple of levers will drop the continuous circuit brushes on the commutator, at the same time pulling away our metal ring. The motor will then start as a continuous current motor; when it has reached its proper number of revolutions or is above it, turn the handle a little further; the continuous current brushes will be raised, the metal ring will connect the commutator bars, and the alternating circuit will be made and the motor will continue to run and will do work.

Now, I consider that the advantages of this plan are these: It makes the motor simple and cheap to build; it will be more efficient and have a greater output than the other motors that have been discussed; the currents to excite the fields will have

to be supplied anyhow, and they cannot be supplied more economically than from the central station; being simpler there will be less liability of derangement.

The motor described by Professor Thomson that I mentioned above consists of field magnets through which the alternating current flows, with an armature not in any way connected with the external source of current, but which has currents induced in it just as if it were the secondary of a transformer. The circuits of all of the armature coils are open excepting one that is in such a position that the current induced in it will be repelled by the pole-pieces. In this form I do not think the motor will be particularly efficient or give any considerable output. It is possible that the principle may be further developed to give a considerable output, but I do not believe that any motor in which the field is fed by alternating currents can be cheaply made, although this is a matter with which I have no experience.

To prevent motors stopping when the load is thrown on it would only be necessary to drive the load from a friction pulley on the shaft of the motor. The pulley should be so adjusted that it will turn just before the motor falls behind its point of its maximum work.

It is possible that all of the plans I have suggested have been tried by the different inventors who are at work on this subject. If a motor of each type that I have mentioned were built and proper experiments were tried upon them, we would—provided we had the ability to interpret and apply our results—have the data necessary to design the best possible machine of each type, and if we build these it should settle the question as to which form will be the best. There is no necessity in building an indefinite number of motors to experiment with. It is too much the custom, if we wish to design a dynamo for instance, to build twenty different ones and see which is best. One machine, with proper experiments and deductions, should put us on the right track.

Dr. Holmes once said that when he had written anything that pleased him it immediately seemed very old indeed. I, with humility, feel much the same way, as if what I had said this evening is so apparent that every one must have known it. I can only hope that some of the suggestions I have made will help the development and final successful application of the alternating current motor.

DISCUSSION.

MR. TOWNSEND WOLCOTT:—I have been very much interested in Doctor Duncan's paper. It throws rather a different light upon the subject of alternating motors from the paper of Mr. Stanley. From Mr. Stanley's paper we concluded that the alternating system, all the way through, was slightly more economical than the direct. But Doctor Duncan has shown, I think pretty conclusively, that there are various losses there which we do not have in the direct system. The loss from heat there, which depends upon the square of the current, I think, is very neatly demonstrated—the work depending on the product of the current and the electromotive force, changing in sign whenever the electromotive force changes, while the loss in heat is constantly plus, because the square of the minus quantity is plus, as well as of the plus quantity. There is one advantage, I think, in the alternating system which is entirely of a practical nature, irrespective of the efficiency, and that is that you do not use any commutator at all. I know one of the greatest practical difficulties in motors and dynamos, is the trouble of having a commutator. Of course, in favorable conditions of working, the commutator may last a long time without need of repair; but, as I have had reason to observe especially of late, in railroad work, the commutator gets played out pretty quick in running street railways. If there is any possibility of running a street railway with an alternating motor, I think it would be a great advantage even if it was not so economical. Even if it lost twenty-five or thirty per cent. of the energy more than the direct motor, I think in some cases it would be preferable.

MR. C. O. MAILLOUX:—I would like to remark with reference to the application of alternating currents to the purposes of electrical traction, to which Mr. Wolcott alludes, that it will probably be some time before we succeed in utilizing it, however great may be the advantage of its use; because the alternating current motor fails to afford one of the chief requirements demanded in a motor, for electrical traction—namely, capacity for producing great torque or effort at the periphery of the armature at the time of starting. This is exactly what the alternating current will not do. Doctor Duncan has pointed out the necessity for gradually putting the load on, so to speak; while as we know, in electrical traction, it is necessary to develop large pulling capacity or effort. There is a great deal of confusion in that

respect as to what is really required of a motor. You may rate a motor at a certain power, and it may be capable of giving you that energy when running at a certain stated speed, yet the motor may be for all that, very far from answering the purposes which it must fulfill in traction, because at the time of starting the car, the effort required is more static than anything else, and while in order to measure kinetic energy by the standard of foot-pounds we must have motion and pressure, or feet and pounds—at the time of starting the car we have only pounds and no feet. In other words, it is a static, dead pull, and the motor must be capable of supplying that pull or else it cannot hope to be successful in propelling a vehicle of any description; and while a motor, as I have just said, might be capable of developing its nominal power, and more than that when running at a given speed such as would propel the car at its rated miles per hour, yet it might prove quite inadequate at the time of starting, and more especially if the car happened to be on a grade or curve, from the very fact that it is not so organized as to be able to develop that effort at the periphery of the armature which is necessary to give the static pull; and that is wherein the alternating current motor does not seem to me to give any hope, at least for the present, and for a considerable portion of the future; because we would have to use machinery, such as friction clutches and various other devices of that kind, so as to gradually apply the work to the motor.

MR. F. B. CROCKER: There are two or three practical points that suggest themselves to me. In the first place, Dr. Duncan refers to the great cost of a laminated field, and he speaks of it as if it were practically a bar to the use of laminated fields. If I were going to make a wrought iron field, or even if I were bidding for a contract to make wrought iron fields in quantities, I should prefer to make them laminated rather than make them of forgings or any other form of wrought iron that I have ever seen used for this purpose—fitting bars together, for instance. So far as I am concerned, I prefer the laminations, and since I have been experimenting a little myself, in this direction, I have been quite pleased with that very feature of the alternating current motors—that they do involve laminated fields.

In regard to the putting on of a load suddenly. That is a difficulty no doubt, and a serious one; but still the load does not go on with the mathematical suddenness that Dr. Duncan assumes.

The belt will slip and stretch more or less and the load will gradually come on. Of course it would be possible to stop a motor, and even bring it to a stand still with a heavy load very suddenly applied—but in ordinary cases where the load is not extreme, it will come on gradually, the motor will take it and I think will run along with it. Of course this is all a question of degree. But I think this difficulty could be overcome more or less. It would be desirable to avoid introducing alternating current motors where they had to suddenly take a heavy load; but that would be, of course, a limitation.

As to the objection that Mr. Mailloux brought up—that an alternating motor must obtain its speed to exert any power or pull—it applies only to one particular kind of alternating current motor. Dr. Duncan enumerated four. I do not remember the classification exactly, but I think Mr. Mailloux's objection only applies to one or two of the four classes. The other two would be entirely outside of Mr. Mailloux's objection. Therefore the alternating current, broadly speaking, is still possible for electric traction; and if an alternating motor of either of the other two classes can be made of sufficient power it would start just as well as a continuous current motor. The question is, can it be made of sufficient power? That is a difficulty with alternating current motors; they have not got the power or torque, as Mr. Mailloux says—they have not got the vigor in them that the continuous current motor has, up to the present time at least; and the problem is to increase their effect—make them more powerful with respect to their size than they are present. The same is true, more or less of alternating current dynamos, I believe. They are large and clumsy for their output. But alternating current motors of the two classes that start themselves are still more clumsy and large for their power, and those are the two classes which I look to as being the ones to improve and to get into practical shape, because I think a motor has got to start itself in order to be useful for practical work, and an auxiliary armature or an auxiliary commutator or any other auxiliary apparatus is a very objectionable thing. Of course if you cannot get along without it you have to accept it, but I think it is very desirable to eliminate it.

MR. MAILLOUX:—I just want to add a word of comment to Mr. Crocker's remarks; that those alternating motors which would be able to start themselves and which he thinks might be able to

develop the torque required are the very ones which are no longer free from the disadvantages of devices for commutating and other troubles of that kind which are incident to the continuous current motor.

Now, as to the production of torque, I think that the objection still holds good, because the trouble of heating as it is related in some way to self-induction—or, at least the production of eddy currents in the mass of the iron itself, even though it be laminated—still applies; and as in order to produce a powerful effort at the periphery of the armature, it is necessary to increase the current very largely, I doubt very much if the curve of torque would be such as you would obtain from a continuous current motor. I fear that it would not rise so quickly and that it would reach the limit very much sooner. Then, besides, I do not see how it would be possible, with the present resources of the art in the present state of its development, to regulate the current, so as to render the use of the motor for that purpose as elastic as the continuous current motor, because, there are a number of limitations or conditions imposed by the current itself which are very hard to overcome.

LIEUTENANT F. J. PATTEN:—Dr. Duncan has shown us that the curve of counter-electromotive force has a variable position with respect to the mean, *i. e.*, oscillating from side to side, and I wish to ask, whether any such oscillation takes place or not, provided the motor is running under a constant load.

DR. DUNCAN:—I think the oscillation will take place no matter what load is on the motor; because in a part of every period—and a period takes place every one three-hundredth of a second—the motor is not a motor at all, it is a dynamo. That is, it is absolutely putting current into the main line. The only way to get the energy to throw that current into the main line is, by decreasing its speed and drawing from its energy of rotation. Therefore, where it is in the positive areas, it will slow down in speed; where it is in the larger negative areas, it will increase its speed. But the oscillation will occur whether the load is constant or not.

LIEUTENANT PATTEN:—The question is fully answered with a single exception regarding the high number of alternations. I would presume that the oscillation referred to is infinitesimal in its character and would make no difference in the practical regulation of the motor in a finite amount of time.

DR. DUNCAN:—If the motor were driving a load which had

a considerable inertia—any revolving apparatus which had a considerable inertia compared with the amount of work—the amount of the oscillation would be infinitesimal. But if the motor were light and were lifting a heavy weight, then the amount of oscillation would be very noticeable, and would seriously decrease the maximum work which the motor could do.

MR. CROCKER:—As regards the regulation of motors, and the point which Mr. Mailloux brought out, it happens that one form of alternating current motor that I have been working upon lately is particularly well adapted to being regulated. One of the most desirable means of regulation in any motor can not be used in an ordinary direct current motor, on account of sparking, that is, shifting the brushes. When we regulate a motor by shifting the brushes, it creates very serious trouble there, because we pass off the non-sparking point on to the sparking zone, and that is very objectionable, because that is really the great difficulty, as some of the speakers have said, in all motors and dynamos with the commutators and brushes It happens that one form of alternating motor works in just the opposite way exactly and as you decrease the power you decrease the sparking, and when you reverse it there is no sparking at all. Therefore you can regulate it in that way, which is just the way every one wants to regulate the motors if he could.

MR. MAILLOUX:—How about the torque?

MR. CROCKER:—I admitted before, and I now readmit that small power and torque is the difficulty with alternating current motors; they have not at present got the power of direct current motors, or, at least they apparently have not got the power. But still, dynamos and direct current motors were very weak in their early stages. When there is something to start on it is generally possible to add five per cent. here and five per cent. there, and, in this way, gradually coax the result up to a respectable magnitude.

MR. S. S. Wheeler:—There has been considerable discussion about the torque of an alternating current motor, and Mr. Mailloux prefers the direct current motor for his car, because when the car is going slowly, the motor going slowly will draw a heavier load and will give a tremendous power momentarily. There are two classes of direct current motors, one of which does not increase its torque when the speed is slow, and the other does increase its torque—the constant current and the constant poten-

tial motors. The alternating motors which have been described seem to resemble the constant current motors in having a constant torque. I would like to ask Dr. Duncan to give us a little information about what can be done in shifting the proportions or changing the design of alternating current motors to make them resemble more closely the constant potential motors, so that greater torque will be secured when the motor goes slower.

LIEUTENANT PATTEN:—I have designed a form and made some elementary tests of a motor, of the kind suggested by Prof. Elihu Thomson in his paper read before the Institute last spring. I have always regarded Professor Thomson's motor with a great deal of admiration. It would seem from some of the discussions we have listened to, that whatever work we are going to get out of an alternating system, must be a question of difference between two factors opposed to each other—the self-induction of the circuit and the power generated as well as the heating. Inasmuch as all our results must be due to the difference between the two quantities, I have worked upon that line, trying to give that difference its greatest possible chance to do some work. If you will remember, Professor Thomson's motor, as Dr. Duncan has explained it to-night, consists in a fixed field and a revolving armature, the circuit of which was closed when it came into position of action; at that point the circuit is momentarily closed.

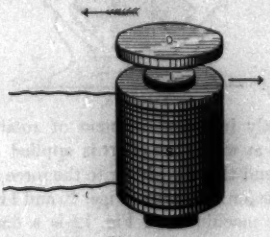

Figure 9.

Fig. 9 illustrates this principle. *S* is a solenoid with a soft iron core *I*, and *D* is a closed circuit of high self-inductive capacity, preferably a copper disc. When alternating currents are sent through the coils of the solenoid *S*, and the centre of the disc *D* is not immediately in the prolongation of the axis of the solenoid, there is a tendency to separate, as indicated by the two arrows. As in all forms of alternate current dynamo-electric

machinery, the effective effort is always due to a difference between two unequal and opposing actions, so in any machine in which the principle thus described finds application, the rotary torque or moment of rotation will be due only to a difference of two efforts, as shown in the preceding analysis; and the machine here illustrated is a simple mechanical arrangement of parts, the purpose of which is to cause this tangential effort, however small, to work at a possible maximum of advantage. Those who recall the forms of machine illustrated in a former lecture and based upon this principle, will remember a form of machine not differing widely from the ordinary direct current machine. The armature placed at the centre of the machine consisted of a number of coils of high self-inductive capacity, the different circuits of which were closed in succession as they arrived in the position of maximum repulsive action. In the machine I have designed the application of the same principle is reversed with the apparent effect of producing a more continuous rotary effort,

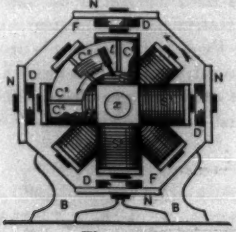

Figure 10.

as well as a greatly increased moment of rotation by virtue of placing the point at which the effort is applied farther from the axis of rotation, and thereby giving to the force at work, however small, a much greater lever arm. Figs. 10 and 11 are end and side elevations of the machine, and Fig. 12 is a diagram of circuits and connections. A polygonal frame *F F F* is connected by lateral strips *N N*, and all is supported upon the base *B B*. Secured to the lateral stripes *N N* are two sets of copper discs *D D* and *d d*. These discs constitute the armature of the machine; they are arranged peripherally, as shown, fixed to the frame structure, and consist of circuits of high self-inductive capacity that remain perfectly closed.

A spindle *x x*, Figs. 10 and 11, carries a revolving switch

C^1 C^2, or sunflower which is secured to the spindle and turns with it. This sunflower commutator constitutes one terminal of the machine, while an insulated ring b +, and its contact brush secured to the support P P, constitutes the other. Under each

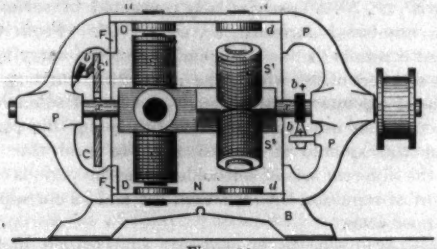

Figure 11.

set of discs, D D and d d, and secured to the spindle x, is a set of solenoids. Those of one set being placed at an angle of 45 degrees to those of the other set, from which it results that these two sets of solenoids will each come alternately into action with respect to its own set of copper discs. Each set of solenoids has its four coils connected in series and the two sets are arranged in two independent circuits. Both have one terminal secured to the

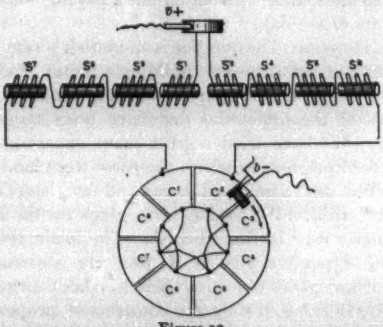

Figure 12.

contact b +, and the other terminal to the alternate segments of the revolving sunflower. This system of connections is shown in Fig. 12, in which the eight-part commutator is shown with alternate segments connected to each other in separate series; the

coils S^1, S^3, S^5, S^7, form one set of revolving solenoids connected in series from the rubbing contract $b+$ which forms one terminal of the machine, to the commutator segment C^1, and thence to all the odd numbered segments. In like manner the other set of solenoids S^2, S^4, S^6, S^8, are similarly connected in series to all the even numbered segments, C^2, C^4, C^6, C^8. From this arrangement it results that as the spindle revolves, carrying these solenoids as a sort of fly wheel, the alternating current will be sent in rapid succession first through one set of solenoids, and then through the other, and by suitably placing this commutator upon the spindle it can be made to send the current through the different sets of solenoids during the periods of maximum effort of repulsion between each set and its corresponding set of copper discs.

The moment of rotation is evidently a maximum under this system of construction, and by increasing the number of sets of solenoids that follow each other in action, the effort of the rotary torque may be made nearly continuous and constant.

It is evidently not contemplated that this motor shall drive horse cars. Its efficiency is not high, and its form renders such an application quite impossible, but it can find a place in the smaller industries, where light motors fill a definite requirement, and render an alternating current circuit a paying one during the working hours of the day.

MR. R. M. HUNTER: The question is one which is very familiar to me practically. I am at present building a motor of eight horse power for our work in Philadelphia which I think will overcome a great many of the difficulties that have been suggested here this evening. We have tried a great many experiments, in motors having field magnets in which the cores were laminated and also solid. We used laminated cores and we have abandoned them for solid cores. We used solid forgings for the field cores. But we formerly used laminated cores. The laminated cores are slightly more expensive, that is if properly constructed; but they have not the great objection that has been urged against them here this evening, if they are constructed properly. That is to say you can adopt a mechanical construction for the cores of these field magnets which is economical. In our connections of motors with a car, we can get three-fourths of a revolution of the armature shaft before the car need start in motion. Therefore we can get a start with the motor before the full load is thrown

upon it. Of course, in practice, the car gradually starts; but at the same time we do get that effect. We start our motor and get a certain number of revolutions without a particle of movement in the car. I certainly expect to see an alternating current motor used on electrical cars. The question of alternating motors with secondary generators is one that has been familiar to me for a good many years., and one which I have looked forward to as a possible future in electrical railroading, particularly on account of the great objection to large conductors where we are using line conductors; that is where we do not propose to use the secondary battery and where we have a large number of cars on the same circuit.

MR. WARING. I fail to perceive the particular advantage in running street cars of applying alternating currents for the transmission of power. The principal advantage of the alternating system is lost when the E. M. F. has to be reduced, and in the present state of the art of electric transmission of power it is not practicable to transmit power—even continuous currents—at any higher electromotive force than probably seven hundred volts, especially in street railways, with bare over-head conductors. Therefore I would like to say that I cannot see any particular advantage in using an alternating current when a continuous current will do.

MR. WHEELER:—As Dr. Duncan's explanations are so clear, I think it would be interesting to have him continue, and I would like to have him tell us something about the comparison of the torque of the alternating current motor with the direct constant current and the direct constant potential motors, if he is willing.

DR. DUNCAN:—With regard to using alternating current motors for street cars, I cannot see the advisability of using them at present, until we know a good deal more about them, while we have continuous current motors which I think very much better adapted to the work.

With respect to the torque of the alternating motor; it will be a maximum when the period of the electromotive force is the same as the period of the counter-electromotive force. For instance, if you have two curves, that (illustrating) representing the curve of the main line or the curve of the dynamo which is supplying the car, we cannot get a greater maximum product than by using a curve whose period is the same and whose phase is not very different. If we had a number of reversals of the impressed

E. M. F. that way, (illustrating) of course, the product would be very much less. The greatest torque will be then when the reversals of the counter-electromotive force are the same as the reversals of the current; that is when the motor is at its normal speed. Of course, for street car work we want to start at a very slow speed, and with an ordinary type of alternating motor—I do not refer to any special types which have been brought forward and more or less described—but with an ordinary type of alternating motor the torque at first is very small indeed; and again, if we are to feed our motor from a determinate source of power, I do not see myself how we can make the torque great at a slow speed. Of course, if we make the current an alternating current by commutating after it gets on the car, then the period of our alternation of electromotive force and counter-electromotive force, can be made the same, no matter what speed we use. But if we are to drive that motor from a dynamo that has a rapid number of reversals, I cannot see that the torque will be great, unless the dynamo has in reality reached its maximum speed. For the maximum work which can be obtained from an alternating motor, Mr. Hutchinson has kindly worked out the problem and finds that if we make the ordinary suppositions and work the motor at its maximum, the expression for maximum work is a very simple one, $\frac{E^2}{8R}$, where E is the maximum value of the electromotive force and R is the resistance of the machine. It is independent of the self-induction or of any other data, providing we build the machine so that it will give the maximum work. There are conditions which Mr. Hutchinson finds in his equations which will enable us to design a machine to give this maximum work. After we have designed it, the maximum work to be obtained is $\frac{E^2}{8R}$. That is about equal to the work that would be obtained from a corresponding source by a continuous current motor.

There is another very curious thing; in order to get the maximum work from a motor—taking some results which we have obtained from a Siemens alternating dynamo—the counter-electromotive force should be greater for this particular case than the electromotive force of the dynamo. If the electromotive force of the dynamo is one thousand volts, we find that the counter-electromotive force should be almost fifteen hundred volts. The

torque, as I said, would be greatest when the machine is running at its full number of revolutions.

Mr. Crocker speaks of an alternating current motor, when a load is suddenly thrown on, gradually bringing the load up to its maximum speed, and the belt squeaking. If he tries the experiment he will not find that the belt squeaks, but the motor will suddenly stop, for unless the load is brought up to its full number of revolutions in one period of reversal—in the Westinghouse system, in $^1/_{300}$ of a sec nd—the motor will stop. Of course some arrangement has to be advised to prevent this. Mr. Crocker speaks too, of only using these motors where the maximum load will not be thrown on suddenly. Of course that is limiting their use in such a way that the motors could hardly be commercially applied.

I cannot see that an alternating motor such as I have described, that is a dynamo working backwards with a continuous current to start it and excite the field, will not be at once practical. You might say that the plan complicates the motor by putting an additional commutator upon it. But the commutator is of the simplest kind. There is no wear of the brushes except in starting it, because after the machine is started the brushes are raised; after it has reached its full number of revolutions, you have no wear of the commutator or sparking at all.

Lieutenant Patten has brought forward a very interesting form of machine, a modification of Professor Thomson's plan, which we cannot but regard with the greatest admiration. The difficulty as I see it now, in such a motor is that, as I understand it, Lieutenant Patten has revolving electro magnets that come opposite copper pieces. Am I right?

LIEUT. PATTEN:—That is the idea.

DR. DUNCAN:—The only difficulty in this is that currents must be induced in those copper pieces in order to cause the revolution of the armature. Now what becomes of the energy of those currents? Evidently it is lost in heat. If the energy of rotation of the motors is very great, the current induced in those pieces of copper is great. Therefore the loss must be great. For myself, I think that the two probable forms of motor are the motor I have described and some modification of Professor Thomson's motor. Whether Lieut. Patten has arrived at that modification I do not know, and, of course, cannot tell without further data and experiments.

Mr. Crocker again speaks of the sparking of the alternating motor being a minimum when it is regulated. I do not believe in alternating motors that have commutators, that is, that have a number of bars through which the current is constantly flowing. I have tried experiments with continuous current dynamos worked as motors, and find very little effect from them. In order to get a large output we must have the counter-electro motive force of the motor equal to its self-induction, and that is simply impossible in practice. If you join up an ordinary series motor with a source of alternating electromotive force, and then with a corresponding source of continuous electromotive force; in the first case you can stop the motor by just laying your hand on it; with the continuous current you have a comparatively immense power.

With regard to laminating the cores of fields I am very glad to hear that it is a non-expensive process. I have no doubt, if such is the case, it would have a distinct advantage in alternating dynamos of every class, because the alternations of current in the armature must cause induced currents in the poles, and if we can build a laminated pole more easily than we can a forged pole, I think it would be policy to make all our poles laminated. However, I have had no experience at all on this matter and can hardly discuss it.

Mr Waring made some remarks which embody my sentiments with regard to using alternating current motors for street cars. I do not see the use of an alternating current motor on a street car. The only difficulty in a continuous current motor lies in the commutator and the brushes. There is trouble, I suppose when the car has to go both ways. Now, that is a matter of detail, and with properly constructed brushes there should be very little trouble. If the commutator bars were made hard enough we would have very little wear; if they were made properly we have absolutely no sparking. I think I saw somewhere a reference made by Dr. Hopkinson to a method of preventing sparking. It is well known in laboratory work. There is a brush bridge over the coil. The current goes through the short circuited coil, and through the brush out to the main circuit. Now when the armature reaches a certain position, the short circuited coil is suddenly thrown into the main circuit. The effect is to suddenly change its current, if its current when short circuited is not exactly the same as half the current in the main line. Now a change of current taking place in an infinitely short time,

would develop an infinitely high electromotive force. It does not take place in that time, but rectifies itself by an arc, the current being still partially short circuited. This effect can be ob-

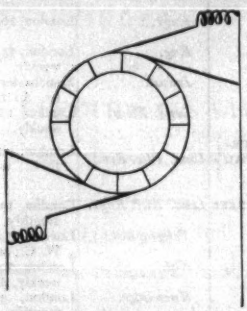

Figure 13.

viated by having behind the main brush another brush; the resistance between them being four or five ohms, or something of the kind, as shown in Fig. 13. Then the current will rectify itself by passing through that auxilliary brush, and though some energy will be lost, still not more than in sparking, and there will be no wear of the commutator.

I think I have answered all the questions that have been asked; and I will say again that I have a firm faith in the ultimate success of alternating current motors, and I think that the two forms to which we must look for results are either simply the dynamo reverse, such as I have suggested, or some modification of Professor Thomson's dynamo. [Applause.]

THE PRESIDENT:—I think it must be a source of great gratification to all of us, as members of the Institute, to see from the records of the society how far the papers which have been brought before us during the past year have served as the basis of those very interesting and important investigations into the subject of alternating currents. The paper which we have had before us this evening has been a very valuable contribution to the literature of the subject, and it has afforded us all very great pleasure and profit to listen to it.

Adjourned.

Reference List of Leading Authorities Cited in the Index of Current Electrical Literature.

NAME.	ABBREVIATION.	PUBLISHED, &c.
Engineer.	*Engr.*	London, 163 Strand, weekly. £1.9.
Engineering.	*Eng.*	London, 35–36 Bedford St. W, C.; weekly. £1.16.
Industries.	*Indust.*	Manchester, 70 Market St., weekly. £1.12.
The Electrician.	*Lond. Elecn.*	London, 1 Salisbury Court, E. C.; weekly. £1.2.
The Telegraphic Journal and Electrical Review.	*Lond. Elec. Rev.*	London, 22 Paternoster Row, E. C.; weekly. £1.1.8.
The Electrical Engineer	*Lond. Elec. Engr.*	London, 139–140 Salisbury Court; monthly. 3d. per issue.
The Telegraphist.	*Telegraphist.*	London, 74–76 Great Queen St., W. C.; monthly, 2d. per issue.
Nature.	*Nat.*	London, 29 Bedford St,, W. C.; weekly, £1.8.
Knowledge.	*Knowledge.*	London, 39 Paternoster Row; monthly, 6d. per issue.
India Rubber & Gutta Percha & Electrical Trades Journal.	*I. R. & G. P. Jour.*	London, 115 Finsbury Pavement, E. C.; monthly. 15 shillings.
The Electrical Engineer	*N. Y. Elec. Engr.*	New York, 115 Nassau St.; monthly, $3
The Electrical World.	*Elec. World.*	New York, 168–177 Potter Building; weekly. $3.
The Electrical Review.	*N. Y. Elec. Rev.*	New York, 13 Park Row; weekly. $3.
The Electric Age.	*Elec. Age.*	New York, 76 Cortlandt St; semi-monthly, $1.50.
Modern Light and Heat.	*Md Lt. and Ht.*	Boston, 178 Devonshire St.; weekly, $3.
Western Electrician.	*West. Elecn.*	Chicago, 6 Lakeside Building; weekly, $2.
Journal of the Franklin Institute.	*Jour. Fkln. Inst.*	Philadelphia, Franklin Institute; monthly, $5.
Science.	*Science.*	New York, 47 Lafayette Place, weekly, $3.50.
Scientific American.	*Sci. Am.*	New York, 361 Broadway; weekly, $3.
Scientific American Supplement.	*Sci. Am. Supp.*	New York, 361 Broadway; weekly, $5.
Mechanics.	*Mech.*	Philadelphia, 907 Arch St.; monthly, $1.
Railroad Gazette.	*R'd. Gaz.*	New York, 73 Broadway; weekly, $4 20.
American Machinist.	*Am. Mach.*	New York, 96 Fulton St.; weekly, $2.50.
Street Railway Journal	*St. Ry. Jour.*	New York, 113 Liberty St.; monthly, $2
Street Railway Gazette.	*St. Ry. Gaz.*	Chicago, 9 Lakeside Building; monthly, $2.
Light, Heat and Power.	*Lt. Ht. and Pr.*	Philadelphia, 413 Walnut Street; semi-monthly, $3.
Progressive Age.	*Prog. Age.*	Philadelphia, 333 Walnut St.; monthly, $2.
Railroad and Engineering Journal.	*Rd. and Eng. Jour.*	New York, 45 Broadway; monthly, $3.
Practical Electricity.	*Prac. Elec.*	Boston, 178 Devonshire St.; weekly, $2.

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Electric Lighting in Germany. Dr. Schilling, German Asso. Gas and Water Engrs. *Lond. Elecn.*, Feb. 24, p. 417.
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Kennedy's Compound Wound Dynamo. (Ill.) *Elec. World*, Feb. 4, p. 54.

There is but one field coil. The machine gives 10,850 watts at 620 revs. per min.

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Note as to successful appeal in Germany against granting a patent to Siemens & Halske for dynamo with internal field magnets.

Automatic Regulation of Dynamo Machines. (Ill.) *Cent. fuer Elek.; Indust.* Feb. 3, p. 123.

Lahmeyer device for making an ordinary shunt wound machine, equivalent to a machine that is over compounded; rise and fall of mercury in a tube varying the resistance of the shunt circuit automatically.

Copper in Dynamos. W. Peukert. *L'Elecn.; Lond. Elec. Engr.*, Feb. 10, p. 135; *Zeits. fuer Elek.*

"It will be observed that machines made about three years ago gave 1 watt for every 30 or 45 grams of copper, whereas the machines of Ganz & Co. at the present day give 1 watt for every 1.6 grams of copper."

The Brown Dynamo Electric Machine. (Ill.) *Prac. Elec.*, Feb., p. 155. (A machine for laboratory and school use.)

Winding Armatures and Polarity of Brushes. (Corr.) "C. A. S." *Elec. World*, Feb. 18, p. 81.

Electro-plating Dynamos. (Ill.) Hanson, Van Winkle & Co. *N. Y. Elec. Rev.*. Feb. 4, p. 9.

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Phenomena of Retardation in the Induction Coil. Disc'n of paper by W. Stanley, Jr., Am. Inst. Elec. Engrs. *Lond. Elec. Rev.*, Feb. 24, p. 206.

On the Difference of Phases of Currents, on the Retardation of Induction, and on the Dissipation of Energy in Transformers, Experimental and Theoretical Researches. (Ill.) G. Ferraris. *Lond. Elec. Rev.*, Feb. 3, p. 111, Feb. 10, p. 132, Feb. 17, p. 156, Feb. 24, p. 191.

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Formulæ for Converters. G. Forbes. Soc. Tel. Engrs. and Elecns. *Lond. Elecn.*, Feb. 24, p. 408.

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The Energy of Alternating Currents. O. B. Shallenberger, Nat. Elec. Lt, Asso. *West. Elecn.*, Feb. 25, p. 101.

The Distribution of Electricity by Alternating Currents. T. C. Smith, Nat. Elec. Lt. Asso. *West. Elecn.*, Feb. 25, p. 100.

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On Alternate Current Transformers with Special Reference to the Best Proportions between Iron and Copper. (Ill.) G. Kapp, Soc. Tel. Engrs. and Elecns. *Lond. Elec. Engr.*, Feb. 10, p. 136, et seq; *Lond. Elecn.*, Feb. 10, p. 338; *Lond. Elec. Rev.*, Feb. 17, p. 170; *Indust.*, Feb. 10, p. 145; *Eng.*, Feb. 17, p. 171, Feb. 24, p. 195.

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Sprague Motors for Mines. (Ill.) *West. Elecn.*, Feb. 18, p. 76.

Plans for an 18-mile motor circuit in the gold-yielding Feather River, Butte County, California; power to be distributed at fourteen points; dynamos driven by turbines.

Electric Motors in a California Gold Mine. *Md. Lt, & Ht.*, Feb. 16, p. 135.

Electric Pumping in Collieries. F. Brain, South Wales Soc. Engrs. *N. Y. Elec. Rev.*, Feb. 18, p. 3.

Electric Transmission of Power in Mines. (Corr.) S. F. Walker. *Eng.*, Feb. 3, p. 114.

Discussion on Electric Power. Inst. Mech. Engrs. *Indust.*, Feb. 10, p. 131.

Losses in Driving Pumps by Electricity. *Indust.; Prac. Elec.*, Feb., p. 162.

Result of the Electric Transmission of Work-Kriegstetten to Solothurn. Report by H. F. Weber. *Lond. Elec. Rev.*, Feb. 17, p. 158.

Electric Transmission of Energy. (Ill.) *N. Y. Elec. Engr.*, Feb., p. 58. Kriegstetten-Solothurn.

The Transmission of Energy Between Solothurn and Kriegstetten. (Corr.) C. E. L. Brown. *Indust*, Feb. 3, p 117.

Efficiency Tests of Electric Motors for Amateurs. (Ill.) W. F. D. Crane. *Elec. World*, Feb. 4, p. 50.; *Lond. Elec. Engr.*, Feb. 17, p. 153;

An Electric Carriage. (Volk's.) (Ill.) *Lond. Elecn.; Sci. Am.*, Feb. 11, p. 82.

Electric Boat for French Admiralty. *L'Electricité; Lond. Elec. Engr.* Feb. 17, p. 148.

An accumulator boat with Krebs motor; weight of electrical apparatus 2891 kilos.

Converting a Holtz Machine Into a Motor *Elec. World*, Feb. 4, p. 55.

Experiment shown at Cornell by Prof. Nichols, reversing the action of an ordinary Holtz machine and converting it into a motor, the charge being obtained from a larger machine driven by water motor.

Alternating Current Electric Motors. (Ill.) L. Duncan, Am. Inst. Elec. Engrs. *Elec. World*, Feb. 25, p. 95; *Prac. Elec.*, Feb, p. 161; *N. Y. Elec. Rev.*, Feb. 18, p. 11; *Science*, Feb. 24, p. 92.

Electricity as a Motive Power. (Prof. Stroud.) *Prac. Elec.*, Feb., p. 157; *Lond. Elecn.*, Feb. 3, p. 312.

Electric Motors. G. A. Liebig, Nat. Elec. Lt. Asso. *N. Y. Elec. Rev.*, Feb. 25, p. 10.

Designing Electric Motors. F. Walker. *Lond. Elec. Rev.*, Feb. 24, p. 188.

Motors for Small Powers in Chicago. *West. Elecn.*, Feb. 4, p. 50.

Some Plain Speaking. (Ed.) *Lond. Elec. Engr.*, Feb. 10, p. 132.

Points out that the time has arrived when all tramway companies seeking economy in good faith must resort to electricity, wherever practicable

The Lineff Electric Tramway. *Elec. World*, Feb. 18, p. 78.

Daft Electric Railway Motors for Pittsburgh. (Ill.) *Elec. World*, Feb. 25, p. 89.

Road has 6-ton motor cars; 1¼ miles in length; grades up to 16 per cent.; a perforated band is placed on the grades with which a movable sprocket wheel engages.

Schlesinger Electric Locomotive Motor. (Ill.) *Elec. World*, Feb. 25, p. 88.

The Fisher Electric Railway at Detroit. (Ill.) *Elec. World*, Feb. 4, p. 51. *St. Ry. Jour.*, Feb.

The road has a third rail supported on insulators and placed in a conduit 8 in. sq. with a slot ¾ in. wide, in which the contact wheel travels.

The Electric Railway at Richmond, Va. *Richmond Dispatch; N. Y. Elec. Rev.*, Feb 11, p. 1.

Sprague Electric Railway in Richmond. (Ill.) *Science*, Feb. 10, p. 68.

Sprague Electric Railway at Richmond. *West. Elecn.*, Feb. 18, p. 75.

The Sprague Electric Railway at Richmond, Va. *Elec. World*, Feb. 11, p. 65.

The Bentley-Knight Electric Railway System. (Ill.) *Elec. World*, Feb. 11, p. 63; *Lond. Elec. Engr.*, Feb. 24, p. 182.

The Bentley-Knight Electric Railway System at Allegheny City, Pa. (Ill.) *Elec. World*, Feb. 18, p. 75; Feb. 25, p. 92.

The Bentley-Knight Standard Truck. (Ill.) *N. Y. Elec. Rev.*, Feb. 11, p. 9.

Electric Traction—Direct Current Working vs. Accumulators. A. Lineff, Instn. Civ. Engrs. *Lond. Elecn.*, Feb. 24, p. 410.

Accumulators on Tramways. (M. Huber's statistics.) *Lond. Elec. Engr.*, Feb. 10, p. 124.

INSTRUMENTS, MEASUREMENTS, &c.

Thomson Bridge for the Measurement of Small Resistances. (Ill.) *Elek. Zeits.; Elec. World*, Feb. 11, p. 62; *Lond. Elecn.*

Siemens and Halske bridge of the Thomson pattern.

Sir Wm. Thomson's New Standard Electrical Measuring Instruments. (Ill.) J. A. Fleming. *Indust.; Elec. World*, Feb. 25, p. 89.

Standardizing Sir W. Thomson's Balances. A. W. Meikle, Glasgow Phys. Soc. *Lond. Elecn.*, Feb. 10, p. 353.

Raworth's Lineman's Galvanometer. (Ill.) *N. Y. Elec. Rev.*, Feb. 4, p. 9.

Eaton's New Ohm-Meter. (Ill.) *Proc. Elec.* Feb., p. 155.

Voltmeter and Controlling Apparatus. (Brueckner, Ross & Co.) (Ill.) *Sci. Am. Supp.*, Feb. 25, p. 10, 131.

On Some Instruments for the Measurement of Electromotive Force and Electrical Power. (Ill.) J. A. Fleming & C. H. Gimingham, Soc. Tel. Engrs. and Elecns.; *Lond. Elec. Engr.*, Feb. 3, p. 116. (Cont'd.)

Portable Voltmeters for Measuring Alternating Potential Differences. (Ill.) Cont'd. W. E. Ayrton and J. Perry, Soc. Tel. Engrs. and Elecns. *Elec. World.* Feb. 4, p. 56, Feb. 11, p. 68.

Irish's Electric Regulator and Meter. (Ill.) *Elec. World*, Feb. 11, p. 66. *West Elecn.*, Feb. 11, p. 62.

A register in which mercury rises and falls, in connection with a series of resistances and clockwork; the mercury being acted upon by the core of a solenoid.

Elementary Testing Suitable for Electric Lighting Systems. (Ill.) T. Gray, *Lond. Elec. Engr.*, Feb. 3, p. 104; Feb. 10, p. 127; Feb. 24, p. 174.

Determination of the Intensity of the Horizontal Component of the Earth's Magnetic Field. T. Gray, Glasgow Univ. Phil, Soc. (Note.) *Lond. Elec. Engr.*, Feb. 17, p. 147.

Apparatus for Determining the Intensity of the Horizontal Component of the Earth's Magnetic Field. T. Gray, Glasgow Univ. Phys. Soc. *Lond. Elecn.*, Feb. 17, p. 391.

Practical Electrical Measurement. J. Swinburne. *Lond. Elec. Rev.; West. Elecn.*, Feb. 4, p. 55.

Electrical Measurements Especially as Applied to Commercial Work. W. A. Anthony, *Jour. Fkln. Inst.; Lond. Elec. Engr.*, Feb. 3, p. 115; Feb. 10, p. 141.

Correct Reading of Needle Instruments. (Ill.) *N. Y. Elec. Rev.*, Feb. 11, p. 7.

Correction for the Length of the Needle of the Tangent Galvanometer. (Ill. Corr.) W. Moon. *Lond. Elec. Rev.*, Feb, 3, p. 127. A. C. Elliott. Feb. 10, p. 152. W. Moon. Feb. 17, p. 182. A. C. Elliott. Feb. 24, p. 215.

Discussion of the Precision of Measurements. S W. Holman. *Tech. Quarterly; N. Y. Elec. Engr.*, Feb., p. 44.

Watts—Heures or Watts—Heure? (Corr.) R. B. P. *Lond. Elec. Engr.*, Feb. 17, p. 159.

Practical Electrical Units. W. B. Esson. *Lond. Elec. Engr.*, Feb. 17, p. 151 (cont'd).

A New Metre. (Note.) *Lond. Elec. Engr.* Feb. 17, p. 136.

As to the system of measurement which M. Freycinet is seeking to introduce, in substitution for the C. G. S. units.

MISCELLANEOUS.

Wonders of Animal Magnetism. G. de la Tourette. *North Am. Rev.*, Feb., p. 131.

Article read and approved by Prof. Charcot.

A New Thermostat. (Ill.) (Nat. Aut. Fire Alarm Co.) ; *Elec. World*, Feb. 4, p. 52.

The Electro-Engraving Machine. (Ill.) *Elec. World*, Feb. 25, p. 90.

The Electrical Typewriter. (Ill.) F. Higgins. *Lond. Elecn.; Sci. Am.*, Feb. 4, p. 73.

The Wallace Electric Cloth Lining. (Ill.) *West. Elecn.*, Feb. 4, p. 50.

An Electric Matrix Making Machine. *Wood and Iron; West. Elecn.*, Feb. 4, p. 57.

Application of Electricity in the Dental Office. G. W. Whitefield, Chic. Elec. Club. *West. Elecn.*, Feb. 11, p. 67.

A New Electric Furnace. (Cailletet.) *Eng.*, Feb. 17, p. 175.
A hollow cylinder of steel hermetically closed, for conducting experiments on different materials at high temperatures while subjected to great gaseous pressures.

An Electric Chess Recorder. *Indust.; West. Elecn.*, Feb. 4, p. 57 ; *Sci. Am.*, Feb. 18, p. 97. (Wurstenberger.)

The Induction Top. (Ill.) *La Nature; Elec. World*, Feb. 4, p. 56 ; *Lond. Elec. Engr.*, Feb. 17, p. 146 ; *Sci. Am. Supp.*, Feb. 25, p. 10, 130.
An iron disc spun in front of a horseshoe magnet is repelled, and assumes an inclined position which it maintains as long as the velocity is sufficiently great.

Submarine Mining—Electrical Arrangements on Shore. (Ill.) Lt. Col. Bucknill. *Eng.*, Feb. 10, p. 131 ; Feb. 24, p. 181.

An Improved Mine Exploder. (Ill.) (D. Moseley & Sons.) *Indust.*, Feb. 17, p. 166.

On the Price of the Factor of Safety in Lightning Rods. S. P. Thompson, Phys. Soc. *Lond. Elecn.*, Feb. 3, p. 330 ; *Elec. World*, Feb. 25, p. 88 ; *Lond. Elec. Rev.*, Feb. 3, p. 126.

Execution by Electricity. *N. Y. World; West. Elecn.*, Feb. 18, p. 76.

Execution by Electricity. (Ed. Note.) *Md. Lt. & Ht.*, Feb. 9, p. 112.

India Rubber Compensators for Overhead Wires. (Corr.) W. H. Preece ; R. S. Bozon. *Lond. Elecn.*, Feb. 3, p. 327, F. Caws. Feb. 10, p. 360.

New Insulated Wires. (Ill.) (Standard Underground Cable Co.) *West. Elecn.*, Feb. 18, p. 80.

A New Weather Proof Line Wire. (Ill.) (Standard Undgd. Cable Co.) *Md. Lt. & Ht.*, Feb. 16, p. 143.

Making Insulated Wires for Electrical Purposes. (Okonite.) (Ill.) *Sci. Am.*, Feb. 25, p. 115.

Insulation. *Md. Lt. & Ht.*, Feb. 16, p. 143.
As to the necessity for better insulation, and the problems to be solved in adapting insulating materials to their work.

Galvanic Belt Frauds. (Corr.) J. Jerritt. *Lond. Elec. Rev.*, Feb. 10, p. 152 ; E. H. Berry, D. G. Fitzgerald, Feb. 17, p. 182.

Electropathic Belts. (Corr.) J. G. Garson. *Lond. Elec. Rev.*, Feb. 3, p. 128.

The Oldest Pioneer. (W. W. Marks.) *N. Y. Elec. Rev.*, Feb. 18, p. 11.

The Men Who Have Helped Edison to Complete His Inventions. *Sci. Am. Supp.*, Feb. 25, p. 10,131.

Dr. Wollaston. (With portrait.) *Lond. Elec. Engr.*, Feb. 3, p. 109.

Dr. Balfour Stewart, F. R. S. (Obit.) P. G. Tait. *Nature; N. Y. Elec. Engr.*, Feb., p. 64.

Franz Carl Guilleaume. (Obit.) *N. Y. Elec. Engr.*, Feb., p. 77.

Electrical Purification of Sewage. *Proc. Elec.*, Feb, p. 166.

Electricity and Sewage. (Webster.) *West. Elecn.*, Feb. 18, p. 79.

The Electrical Sewage Process. *Lond. Elec. Rev.; Sci. Am.*, Feb. 11, p. 85.

Refining Sugar by Electricity. *N. Y. Elec. Rev.*, Feb. 4, p. 1.

The Paris Exhibition of 1889. (Ed.) *Lond. Elec. Engr.*, Feb. 17, p. 157.

Paris Universal Exhibition of 1889. *Lond. Elec. Engr.*, Feb. 10, p. 130.

The Society of Telegraph Engineers and Electricians and the Paris Exhibition of 1889. (Corr.) F. H. Webb. *Lond. Elecn.*, Feb. 3, p. 327.

Patents and Exhibitions. (Corr.) J. K. Fahie & Son. *Lond. Elec. Engr.*, Feb. 24, p. 185; *Lond. Elecn.*, Feb. 24, p. 413: *Lond. Elec. Rev.*, Feb. 24, p. 216.—Danger of exhibiting unpatented inventions.

The Necessity of a Patent System and the Advantage to be Derived Therefrom. *Md. Lt. & Ht.*, Feb. 2, p. 93.

Improvement in Our Patent Laws. A. Steuart, Nat. Elec. Lt. Asso. *West. Elecn.*, Feb. 25, p. 89.

The Annual Report of the Commissioner of Patents to Congress. G. H. Stockbridge. *Elec. World*, Feb. 18, p. 76.

The Patent Reform Question once more. G. H. Stockbridge *Elec. World*, Feb. 4, p. 52.

Limitation of U. S. Patents by Foreign Patents. (Corr.) I. H. Davis. *N. Y. Elec. Engr.*, Feb., p. 73.

An Amendment to the Patent Law. *Md. Lt. & Ht.*, Feb. 16, p. 136.

Mr. Edison on Patent Protection. (Ed.) *N. Y. Elec. Engr.*, Feb., p. 41. *Sci. Am.*, Feb. 25, p. 117.

Mr. Edison on the Patent Law. *N. Y. Evg. Post; N. Y. Elec. Engr.*, Feb., p. 65.

Revision of the Patent Law. C. A. Brown, Chic. Elec. Club; *N. Y. Elec. Engr.*, Feb., p. 60.

Statistics of United States Patents Relating to Electricity in 1887. T. D. Lockwood. *N. Y. Elec. Engr.*, Feb., p. 49.

1,248 electrical and allied patents; a decrease of 89 from 1886; 6.10 per cent. of all the patents issued.

The Magnetic Properties of Iron. (Ledeboer.) *Eng.*, Feb 17, p. 175.

Magnetization of Iron. *Sci. Am. Supp.*, Feb. 4, p. 10,073.
The possible intensity of magnetic induction.

Wire Space in Large Buildings. C. L. Healy. *Elec. World*, Feb. 25, p. 88.

A Diagram for Electric Wiring. (E. B. E. Stark.) *Eng.*, Feb. 17, p. 175.

The Lightning Rod Question. D. P. Heap. *N. Y. Elec. Rev.; Lond. Elec. Rev.*, Feb. 17, p. 162.

An Improved Electric Bell. (Ill.) (Stocker.) *Sci. Am.* Feb. 25, p. 114.

The New "Hub" Bell. (Ill.) (Elec. Gas Ltg. Co., Boston.) *N. Y. Elec. Rev.* Feb. 11, p. 3.

Sunstroke by Electricity. *Jour. des Debats; West. Elecn.*, Feb. 18, p. 80. *Sci. Am.*, Feb. 18, p. 99.

Conference on Technical Education. *Lond. Elec.*, Feb. 17, p. 391.

Another Electrical Laboratory. (Vienna.) *Lond. Elec. Engr.*, Feb. 24, p. 171.

New Physical Laboratory University of Michigan. (Ill.) *N. Y. Elec. Rev.*, Feb. 18, p. 2; *West. Elecn.*, Feb. 18, p. 77.

The Electric Club of New York. *Eng.*, Feb. 24, p. 195.

Electric Club Memories. *N. Y. Elec. Rev.*, Feb. 11, p. 2.

Opening of the New York Electric Club. (Ill.) *N. Y. Elec. Rev.*, Feb. 4, p. 1. *Md. Lt. & Ht.*, Feb. 9, p. 117

The House Warming of the New York Electric Club. *Md. Lt. & Ht.*, Feb. 2, p. 97.

The Electrical and Magnetic Discoveries of Faraday. H. A. Rowland, N. Y. Elec. Club. *N. Y. Elec. Rev.*, Feb. 4, p. 3. *Md. Lt. & Ht.*, Feb. 9, p. 118.

The Term, "Magnetic Resistance." (Corr.) J. Swinburne. *Lond. Elecn.*, Feb. 24, p. 412.

The Use of the Term "Resistance" in the Description of Physical Phenomena. Phys. Soc. R. H. N. Bosanquet. *Lond. Elecn.*, Feb. 17, p. 390; *Indust.*, Feb. 17, p. 166.

On the Heating Effects of Electrical Currents. W. H. Preece, Royal Soc. *Lond. Elecn*, Feb. 17, p. 386, Feb. 24, p. 411.

Letters for Learners and Unprofessional Readers. (Ill.) H. D. Wilkinson. Chap. VII. *Lond. Elecn.*, Feb. 3, p. 320; Feb. 10, p. 349; Feb. 17, p. 375; Feb. 24, p. 408.

On the Position and Prospects of Electricity as Applied to Engineering. W. Geipel, Instn. Mech. Engrs. *Lond. Elec. Engr.*, Feb. 3, p. 113; Feb. 10, p. 130; Feb. 24, p. 183. *Indust.*, Feb. 10, p. 130; Feb. 17, p. 146. *Eng.*, Feb. 17, p. 172; Feb. 24, p. 202. *Lond. Elecn.*, Feb. 10, p 355; Feb. 24, p. 424.

Copper Production in 1887. *Eng. & Mg. Jour.; N. Y. Elec. Engr.*, Feb., p. 65.—Production in U. S. A., in 1887, 177,200,000 pounds.

Electricity and the Law. *Eng.; N. Y. Elec. Engr.*, Feb., p. 77.

Electric Organ Actions. G. Wacker, Poly. Sec. Am. Inst. *Elec. World*, Feb. 11, p. 62.

Alternating Current Circuits and Fire Alarm Wires. (Corr.) "H. W. F." *Elec. World*, Feb. 11, p. 68.

Effects of Animal Organism on Electro-Magnetic Action. C. H. Murray. *Elec. World*, Feb. 18, p. 74.
Advances the theory that "the magnetism of an electric current is entirely extinguished by the passage of the current through an animal organism."

Electric Welding by Means of the Arc. (Ill.) The Benardos process. *Elec. World*, Feb. 25, p. 91.

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Manufacture of Aluminium. *Prac. Elec.*, Feb., p. 159.

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The Institute of Electrical Engineers. (Corr.) S. F. Walker. *Lond. Elec. Engr.*, Feb. 17, p. 159. "Exon," "Electricita," Feb. 24, p. 185.
Admission of ladies to meetings.

Electricity. G. H. Bliss. *West. Elecn.*, Feb. 11, p. 70. Feb. 18, p. 77.

How can we Protect our Watches from the Influence of Magnetism? P. Lange, Nat. Elec. Lt. Asso. *West. Elecn.*, Feb. 25, p. 88.

The Time in Which We Think. *Md. Lt. & Ht.; Sci. Am.*, Feb. 11, p. 81.

Edoux Hydraulic Elevators. (Ill.) *Sci. Am.* Feb. 11, p. 86.
Includes hydro-electrical regulation.

An Improved Electric Circuit Closer. (Stocker.) (Ill.) *Sci. Am.*, Feb. 25, p. 114.

Copper Alloys. (Note.) G. A. Faurie, French Acad. Sci. *Indust.*, Feb. 3, p. 123.

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The Range of Molecular Forces. A. W. Rucker, Lond. Chem. Soc. *Indust.*, Feb. 17, p. 174.

Electric Osmose and Electro-Capillary Action. R. Snowdon, Brit. Asso. Ad. Sci. *Elec. World*, Feb. 4, p. 51; *West. Elecn.*, Feb. 4, p. 56.

On the Effect of Light on the Electric Discharge. E. Wiedemann and H. Ebert, Phys. Med. Soc., Erlangen. *Lond. Elecn.*, Feb. 3, p 324.

On the Optical Demonstration of Electrical Stress. A. W. Rucker, and C. V. Boys, Phys. Soc. *Lond. Elecn.*, Feb. 3, p. 330.

On a Water-Dropping Influence Machine. S. P. Thompson, Phys. Soc. *Lond. Elecn.*, Feb, 3, p. 330; *Lond. Elec. Rev.*, Feb. 3, p. 126.

Note on the Theory of the Electrophorus. E. C. Rimington. *Lond. Elec. Rev.*; *West. Elecn.*, Feb. 4, p. 57.

English and American Practice in Electrical Engineering. (Corr.) W. H. Smith. *Indust.*, Feb. 17, p. 170.

The Heating of Electric Discharging Points. (Semmola.) *Eng.*, Feb. 10, p. 148.

Atmospheric Electricity. Palmieri, Acad. Sci., Naples. *Lond. Elec. Engr.*, Feb. 10, p. 125.

Insists that a negative charge of electricity is produced by the evaporation and a positive charge by the condensation of water. The evaporation and condensation must occur with a certain degree of rapidity in order to develop a perceptible electrical effect.

Electrical and Meteorological Observations on the Peak of Teneriffe. R. Abercromby, Meteor. Soc. *Lond. Elec. Eng.*, Feb. 17 p. 149; *Eng.*, Feb. 17, p. 165.

Earth Current Variations. (Note.) J. J. Landerer. *Engr.*, Feb. 10, p. 148.

Earth Currents and Atmospheric Electricity. (Ed.) *West. Elecn.*, Feb. 18, p. 78.

Comments on the official observations to be made in Spain on earth currents and on atmospheric electricity, as proposed at the Congress of 1881.

Observations on Atmospheric Electricity. L. Weber, Brit. Asso. Ad. Sci. *Sci. Am. Supp.*, Feb. 18, p. 10, 114.

Pittsburgh. *Md. Lt. & Ht.*, Feb. 23, p. 164.

George Westinghouse, Jr. *Md. Lt. & Ht.*, Feb. 23, p. 165.

The Standard Underground Cable Company. *Md. Lt. & Ht.*, Feb. 23, p. 167.

Electric "Sunstroke." (Ed. Note.) *Md. Lt. & Ht.*, Feb. 2, p. 90.

The Price of Copper. (Ed. Note.) *Md. Lt. & Ht.*, Feb. 2, p. 91.

Electrical Terminology Among Physicians. *Md. Lt. & Ht.*, Feb. 2, p. 92.

The Maps of the Ordnance Survey III.—Electrotyping. (Ill.) *Eng.*, Feb. 3, p. 119; Feb. 17, p. 157.

Some Remarks on the Past Year. *Lond. Elecn.*, Feb. 10, p. 134.

Snowstorms. *Lond. Elec. Rev.*, Feb. 24, p. 188.

Osculatory Electricity. *N. Y. Elec. Rev.*, Feb. 11, p. 1.

A New Departure in Brazing and Welding. (Fletcher.) *N. Y. Elec Rev.*, Feb. 11, p. 1.

The Industrial Importance of Electricity. *Indust.*; *N. Y. Elec. Rev.*, Feb. 11, p. 3.

What shall be the Limitation to Human Responsibility? *Md. Lt. & Ht.*, Feb. 9, p. 113.

Winding of Electro-Magnets. (Ed. Note.) *Md. Lt. & Ht.*, Feb. 9, p. 112.

Electricity Directly from Heat. *Science*, Feb. 10, p. 68.

Electro-Magnetic Separators. (Corr.) C. J. H. Woodbury. *N. Y. Elec. Engr.*, Feb., p. 73.

Specific Inductive Capacity. (Ill.) J. Hopkinson, Royal Soc. *N. Y. Elec. Engr.*, Feb., p. 61.

The Radial Distribution of Variable Currents in Thick Wires. (Stefan.) Vienna Acad. *Lond Elecn.; N. Y. Elec. Engr.*, Feb., p. 63.

Polarization. (Experiments of F. Strenitz.) (Note.) *Lond. Elec. Engr.*, Feb. 10, p. 122.

Effect of Current on Wine. (Note.) F. Mengarini. *Jour. Chem. Soc.; Lond, Elec. Engr.*, Feb 24, p. 172.

Current passes through the wine; proportion of alcohol thereby diminished, a perfume imparted to the wine similar to that acquired by maturing; coloring matter is affected, and the wine is put in a better state of preservation.

Action of Sea Water upon Cast Iron. C. N. Draper. *Chem. News; Sci. Am.*, Feb. 4, p. 64.

New Discovered Records of Magnetic Declination. *Science; West. Elecn.*, Feb. 18, p. 81.

Records made in 1714 off the coast of Mexico.

Electrified Balsam. (Boys.) *Sci. Am.*, Feb. 18, p. 106.

The Velocity of Electricity. (Note.) *N. Y. Elec. Rev.*, Feb. 18, p. 2.

Electrical Rotary Motions. (Ill.) W. Moon. *Lond. Elec. Rev.*, Feb, 24, p. 193.

Action of Magnets on Liquids. *Lond. Elec. Rev.* Feb. 10, p. 147.

Morehead experiments.

BATTERIES, ELECTROLYSIS, &c.

The Schanschieff Battery. *Sci. Am. Supp.*, Feb. 11, p. 10,095.

Abst. of report by W. H. Preece.

A Soap Battery. A. V. Meserole. *Elec. World*, Feb. 18, p. 78.

Battery Carbons. (Corr.) H. Liepmann, G. J. Atkins. *Lond. Elecn.*, Feb. 17, p. 389.

Mr. Case's Carbon Battery. *Sci. Am. Supp.*, Feb. 4, p. 10,073.

Electric Energy From Carbon Without Heat. W. E. Case, Am. Inst. Elec. Engrs. *N. Y. Elec. Engr.*, Feb., p. 50, 74.

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Letter from Prof. J. W. Gibbs to the Secretary of the B. A. Electrolysis Committee as to "a perfect or reversible galvanic cell."

The Treatment of Antimony Ores by Electrolysis. *Lond. Elec. Engr.*, Feb. 3, p. 101.

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Experiments on the Possible Electrolytic Decomposition of Certain Alloys. (Ill.) W. C. Roberts-Austen. *Elec. World*, Feb. 4, p. 53.

Electrolysis of Iron Salts. A. Watt. (Cont'd.) *N. Y. Elec. Engr.*, Feb., p. 65.

On Ohm's Law in Electrolytes. (Ill.) D. G. Fitzgerald, Brit. Asso. Ad. Sci. *Lond. Elecn.*, Feb. 17, p 385.

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Nickel Plating Solutions. *Bul. Inter. de l'Elec.; Elec. World*, Feb. 25, p. 94.

Farbaky and Scheneck's Accumulator Plates. (Ill.) *Lond. Elec. Rev.*, Feb. 24, p. 194.

The Storage Battery. *N. Y. Elec. Rev.*, *Sci. Am.*, Feb, 18, p. 102.

Drake and Gorham's Switchboard. (Ill.) *Lond. Elec. Engr.*, Feb. 10, p. 131.

A switchboard designed for accumulator installations

The Julien Storage Battery. *Prac. Elec.*, Feb., p. 161.

A New Form of Secondary Battery. K. Hedges, Brit. Asso. Ad. Sci. *N. Y. Elec. Engr.*, Feb., p. 59; *Prac. Elec.*, Feb., p. 160.

Drake and Gorham's Excess Indicator. (Ill.) *Lond. Elec. Engr.* Feb. 24, p. 182.

For secondary battery protection; the principle adopted is that of thermic alarms, which depend for their action upon the bending of a compound metallic plate under variations of temperature.

THERMO-ELECTRICITY.

On the Effect of Magnetization on the Thermo-Electrical Properties of Bismuth. H. Tomlinson, Phys. Soc. *Eng.*, Feb. 3, p. 128; *Lond. Elecn.*, Feb. 3, p. 330, *Elec. World*, Feb. 25, p. 92; *Lond. Elec. Rev.*, Feb. 3, p. 125.

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"Every man is a debtor to his profession, from the which as men do of course seek to receive countenance and profit, so ought they of duty to endeavor themselves by way of amends to be a help thereunto."

LORD BACON.